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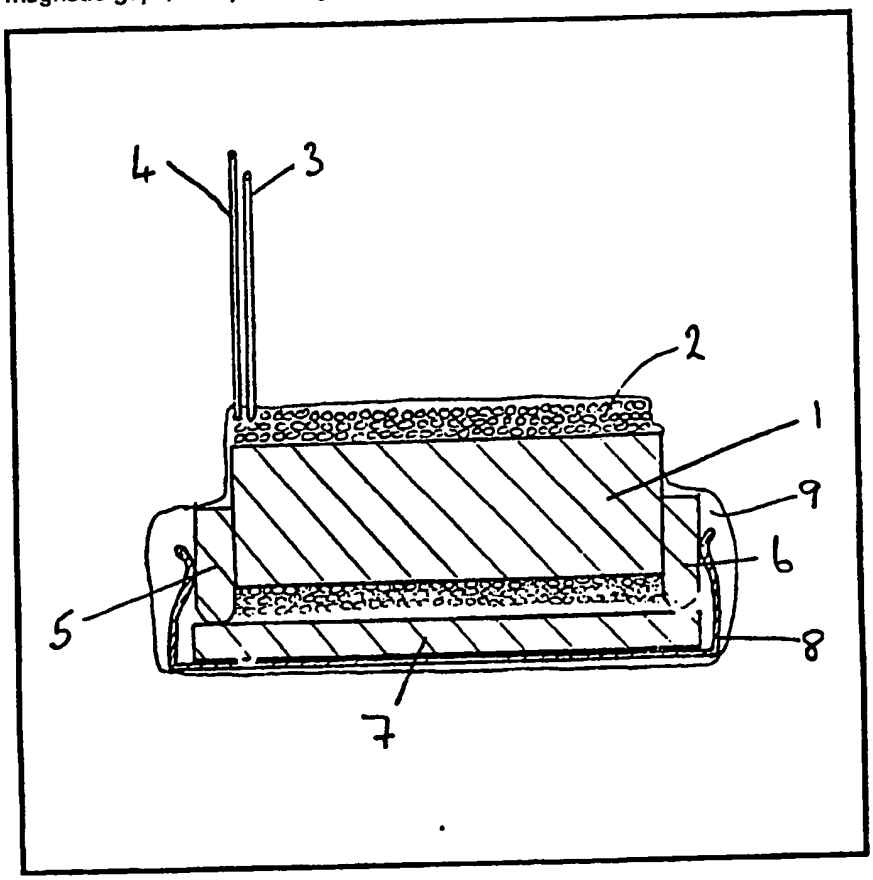
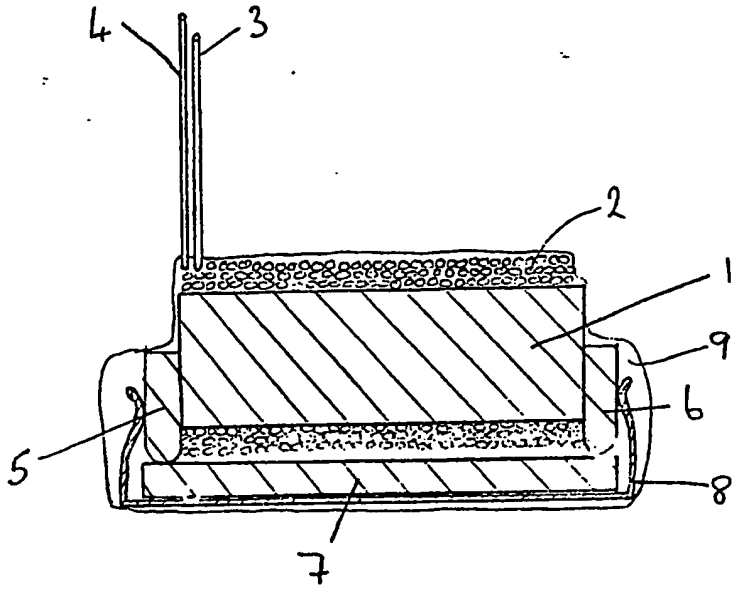
(54) Inductive suppression devices

(57) An inductor device particularly suitable for use as a suppressor with thyristor switching devices comprises a coil 2 wound on a magnetically susceptible core leg 1, the ends of said core leg being joined by a separate bridge 5, 6, 7 of magnetically susceptible material to provide a continuous magnetic path. The magnetically susceptible material is suitably ferrite and the number of turns wound on the core leg should be such as to give the maximum magnetic field without saturation in the continuous magnetic path occurring. The core is held by a steel clip 8 and is encapsulated 9. The permeability of the core may be adjusted by suitably reducing the area of contact between the core parts; by using non-magnetic gaps; or by misalignment of core parts.

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SPECIFICATION

Inductive suppression devices

The present invention relates to inductors for use in electric circuits and more particularly to inductors for use as suppression devices in thyristor controlled circuitry.

The use of thyristor devices such as triacs to control the power flowing into a load from an electric power supply is well known. They are commonly used in applications such as electric lamp dimming switches and electric motor speed control devices. However, when used in phase controlled circuits they generate a spectrum of harmonics of the supply frequency which give rise to mains borne interference affecting control and communications systems and causing deterioration of radio and television reception by appearing as background noises. The problem is sufficiently serious to have given rise to regulations in many countries governing the permitted acount of noise generation from such thyristor controlled circuits.

It is known that a degree of suppression of these harmonics can be achieved by connecting one or more inductor-capacitor units in circuit with the thyristor device. However, hitherto it has proved difficult to meet the existing and proposed legislation on noise suppression with such a system.

In my earlier United Kingdom Patent No. 1514161 I describe a system utilising an inductor which comprises a pair of coils wound on magnetically susceptible, substantially parallel core legs, the two core legs being joined at each end by separate, magnetically susceptible core yokes of smaller cross-section area than the core legs to provide a continuous magnetic path. This system is capable of providing suppression to the existing standards but, although less bulky than prior inductor suppressors, it is still relatively large compared with the space available in a typical thyristor controlled domestic light switch.

It is an object of the present invention to provide an inductor which can be used to further improve the suppression of interference in thyristor controlled circuits. It is a further object of the present invention to provide an improved inductor device which is easier and therefore less costly to manufacture, which does not necessarily need to be manufactured to such close tolerances as hitherto, and yet which still provides improved performance as an inductor suppressor.

According to the present invention an inductor comprises a coil wound on a magnetically susceptible core leg, the ends of said core leg being joined by a separate bridge of magnetically susceptible material to provide a continuous magnetic path.

Preferably at least part of the said bridge is arranged substantially parallel to said core leg.

The magnetically susceptible material used for the core and the separate bridge used to complete the magnetic path, can be any of the materials of relatively high magnetic susceptibility well known as core materials in inductive devices operating at frequencies above 0.1 Mc/S. Particularly suitable are the synthetic materials known as ferrites which have electrical conductivity properties which reduce the occurrance of eddy currents. Materials of the same or different magnetic susceptabilities and other magnetic properties can be used for the core leg and the bridge.

The core leg can be of any suitable configuration, although a cylindrical core leg is preferred for ease of coil construction and subsequent assembly. The bridge can be formed in one piece, for example as a generally 'U' shaped member, with the core leg either fitting within the arms of the 'U' or bridging the ends of the said arms, in which case, the ends can either be radiused to accommodate the core leg, if cylindrical, or if desired, can be plane faced, optionally with 'flats' ground onto the core leg, to give a tangential contract and controlled reduced magnetic path.

Alternatively the 'U' shaped member can be used as the core leg and a joining piece used as the bridge.

As an alternative to 'U' shaped pieces, an assembly of differently shaped pieces of magnetically susceptible material can be used to form the required bridge constituting the continuous magnetic path.

A further alternative is the use of two 'L' shaped members, one functioning as the core leg with the coil wound upon it, the other as the bridge member. In all the configuration suitable for use in the inductors of the present invention, it is found that the performance of the inductors can be advantageously modified by using a restricted area of contact between the selected pieces of magnetically susceptible material.

The single coil can be wound in any suitable insulated conducting material, for example insulated copper wire, particularly lacquered copper wire. The number of turns wound on the coil should be sufficient to produce the desired suppressive effect by inducing a sufficiently strong magnetic field in its core leg to reach a point just short of magnetic saturation in the continuous magnetic path.

Care should also be taken to ensure that the coil can handle the maximum power in the circuit in which the inductor is to be used, and in particular to not generate excessive heat. If excessive heat is generated it can have two deleterious effects. Firstly, it can constitute a fire hazard because of the generally enclosed location in which the inductors of the present invention are used, and secondly, the magnetic performance of magnetically susceptible materials such as ferrites

decreases with increasing temperature, and therefore the performance of the inductors can decrease. The size of the coil for an inductor for any particular suppressive application can readily be determined by experiment.

The core members of the inductors of the present invention can be held in the correct spatial relationship by any suitable means, for example spring metal clips, plastic frames and encapsulation in plastic resins, any of these methods being used alone or in combinations.

A particularly preferred method of maintaining the spatial relationship of the conductors of the present invention is to encapsulate them either wholly or partially in an unsaturated polyester or other thermosetting or chemically cured resin based plastics material. It has further been found advantageous, i.e. in that both the suppressive performance is improved and the audible noise produced by the inductor is reduced, if the unsaturated polyester or other thermosetting or chemically cured resin used is a plasticised resin.

The size of the core leg, that is to say its length and cross-section area, the number of turns in the coil wound thereon and the size and configuration of the material used to form the continuous magnetic path can be varied to alter the inductive and other characteristics of the inductor. Further, these characteristics can be altered by departing from flat planar joining surfaces between the pieces, of magnetically susceptible material to reduce the area of contact between them and therefore reduce the permeability of the continuous magnetic path. Alternatively other means of controlling the permeability of the magnetic path can be used, for example either by the introduction of pieces of non-magnetic material, such as a thin section of plastics material between two or more of the core pieces or alternatively by the arrangement of a specific air gap between two or more of the core pieces, which gap is greater than the unavoidable air gap which is present when any two pieces of magnetically susceptible material are maintained in physical contact with each other.

Additionally, useful changes in these characteristics can also be obtained by the misalignment of the various core pieces, in order to locally reduce the effective cross-sectional area of the core in one or more places. All these factors can be readily adjusted to enable the construction of an inductor device according to the present invention, having the maximum suppressive effect for a given range of frequencies. It is believed that the inductors of the present invention function by the generation of a sufficient magnetic field which delays the virtually instantaneous switching of electric currents achieved by the use of thyristor based switching circuits, which magnetic field is generated without saturating the magnetically susceptible core of the inductor, and thereby preventing decay of the induced field before the next thyristor switching operation.

The present invention is further an arrangement for controlling the power to a load in an electric circuit comprising a thyristor switching device and an inductor comprising a coil wound on a magnetically susceptible core leg, the ends of said core leg being joined by a separate bridge of magnetically susceptible material to provide a continuous magnetic path. Preferably at least part of said bridge is arranged substantially parallel to said core leg.

In a further aspect of the present invention, a capacitance can be used in conjunction with the inductor and the thyristor to increase the suppression of the noises generated, by the thyristor.

It is a particularly advantageous aspect of the present invention that the capacitances used with the inductors can be lower values than those used hitherto. For example capacitances in the range 0.01 to 0.1 uF have been found to give useful results.

The inductor is suitably connected into the circuit to give the maximum suppressive effect within that circuit.

The present invention is further illustrated with reference to the accompanying drawing which shows a cross-section of an inductor according to the present invention.

The induction comprises a cylindrical core leg 1, of diameter 0.5" and length 1.25" made from Ferrite, grade F6 supplied by Neosid Limited, having wound thereon a coil 2 comprising 4 layers of 0.6 mm diameter lacquered copper wire the ends of which, 3, 4, are available for connection into an electrical circuit. A bridge member is provided by 3 separate pieces of F6 grade Ferrite; two end pieces 5, 6 being of a generally rectangular cross-section, 0.125" × 0.300" with one small edge radiused as shown, each piece being 0.280" wide and a third piece 7, being a rectangular slab of cross section 0.435" × 0.135" and 1.485" long. The assembly is held in the correct spatial relationship by a steel clip 8. After assembly, the whole inductor is temporarily immersed in an unsaturated polyester resin solution containing 50% saturated polyester plasticiser, and then placed in a mould. On curing the resultant encapsulation 9 comprises a moulded part surrounding the bridge and a thin coating on the remainder of the inductor.

When such an inductor was used in combination with a 0.047 uF capacitor as a suppressor for a 500 Watt thyristor controlled 'Varilight' light dimming switch (manufactured by Doyle and Tratt Products Ltd.) to power 500 watts of tungsten filament lighting load, the resultant radio interference was within the limits specified in B.S. 800 (1977).

CLAIMS

1. An inductor comprising a coil wound on a magnetically susceptible core leg, the

ends of said core leg being joined by a separate bridge of magnetically susceptible material to form a continuous magnetic path.

2. An inductor as claimed in claim 1 wherein at least part of said bridge is arranged substantially parallel to said core leg.

3. An inductor as claimed in claim 1 or 2 wherein the core leg and the separate bridge are made of ferrite material.

4. An inductor as claimed in any one of the preceding claims wherein the core leg is cylindrical, of any curved or straight sided cross-section.

5. An inductor as claimed in any one of the preceding claims wherein the separate bridge is a 'U'-shaped member.

6. An inductor as claimed in claims 1 to 4 wherein the bridge is formed from an assembly of separate differently shaped pieces of magnetically susceptible material.

7. An inductor as claimed in claims 1 to 3 wherein the core leg is formed by one arm of an 'L'-shaped member and the bridge is formed by the other arm in conjunction with a second separate 'L'-shaped member.

8. An inductor as claimed in any one of the preceding claims wherein the area of contact between selected pieces of magnetically susceptible material is restricted.

9. An inductor as claimed in claim 8 wherein the joining surfaces between the pieces of magnetically susceptible material are not flat planes.

10. An inductor as claimed in any one of the preceding claims wherein the coil wound on the core leg contains sufficient turns to produce the maximum field in its core leg without causing magnetic saturation of the continuous magnetic path.

11. An inductor as claimed in any one of the preceding claims wherein the inductor is wholly or partially encapsulated in an unsaturated polyester or other thermosetting or chemically cured resin based plastics material.

12. An inductor as claimed in claim 1 and substantially as described in the description with reference to the drawings.

13. An inductor as claimed in any one of the preceding claims when used in combination with a thyristor switching device to control the power supplied to a load in an electric circuit.

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